(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
30 November 2000 (30.11.2000)

PCT

(10) International Publication Number
WO 00/71235 A1

(51) International Patent Classification[7]: B01F 3/04, C02F 3/20

(21) International Application Number: PCT/GB00/01755

(22) International Filing Date: 8 May 2000 (08.05.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
9911649.3 20 May 1999 (20.05.1999) GB
9920840.7 4 September 1999 (04.09.1999) GB

(71) Applicant *(for all designated States except US)*: **STEM DRIVE LIMITED** [GB/GB]; Solway Works, Eastriggs, Annan, Dumfriesshire (GB).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **GRAHAM, Hind** [GB/GB]; Solway Works, Eastriggs, Annan, Dumfriesshire (GB).

(74) Agents: **WADDINGTON, Richard**, et al.; Appleyard Lees, 15 Clare Road, Halifax HX1 2HY (GB).

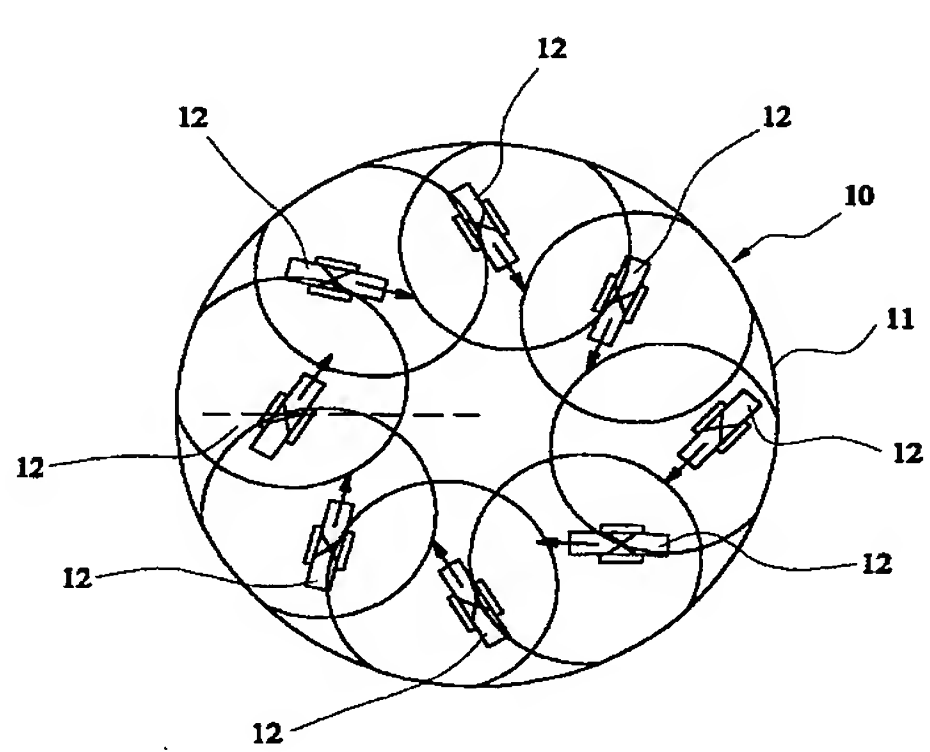
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

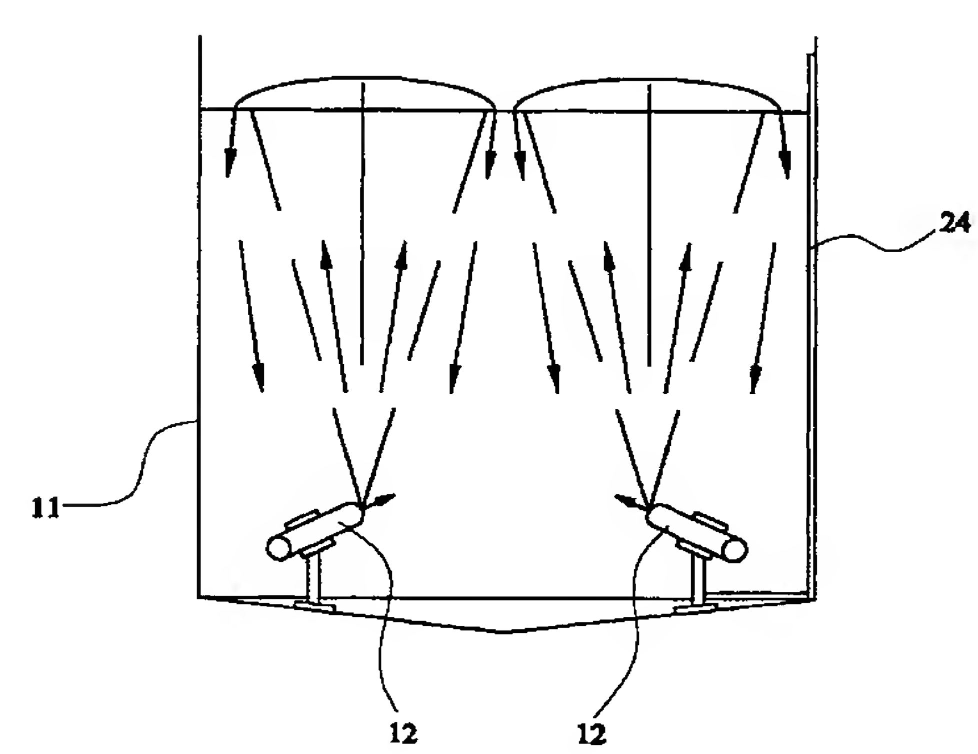
(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: FLUID MIXING SYSTEM





(57) Abstract: A fluid mixing system for use in waste water treatment comprises an array of pneumatic fluid jet mixers (12) located on the base of a digester tank (11). The jet mixers (12) are directed at approximately 45° from the radial alignment and approximately 15° above the horizontal and Bio-gas, for example, methane, NO_x and/or SO_x gases, is supplied to the mixers (12) from an external supply. The gas ejected from the mixers (12) entrains a flow of the waste material, which results in the effective mixing thereof.

WO 00/71235 A1

FLUID MIXING SYSTEM

This invention relates to a fluid mixing system and to a method of mixing fluid material, particularly, but not limited to, a fluid mixing system for use in waste water treatment and a method of mixing waste water.

In waste water treatment systems, waste water, typically in the form of sewage, is processed in tanks known as digesters. In a digester the sewage is broken down and processed by microbial action.

In existing digesters, material is simply allowed to stand in the tank to be digested. Problems arise with this method because a crust forms, which crust may be 3 metres thick in a digester which is 30 metres deep and 25 metres across. The presence of such a crust inhibits the release of methane which is produced during processing.

A further problem with existing digesters is that the tank "grits-up" when grit in the material settles to the bottom and must be dug out periodically. This leads to undesirable down time of the digester.

An attempt to overcome the above mentioned disadvantage involves the use of a gas supply lance which is used to feed bio gas from a gas supply to the bottom of the digester tank to encourage mixing of the material in the tank. From the open end of the lance, the gas makes its way to the surface of the material.

Disadvantages arise with this system because the mixing method is very ineffective, with only a limited portion of the material in the digester being mixed.

It is an object of the present invention to address the abovementioned disadvantages.

According to one aspect of the present invention a fluid mixing system for a tank containing fluid material comprises at least one pneumatic mixer operable to be located within said fluid material and arranged to eject gas supplied to the or each mixer at an angle to the vertical to thereby entrain a flow of fluid material within the tank to cause mixing of said fluid material.

The system may be a waste fluid mixing system. The tank may contain a mixture of fluid material and solid material, the mixture may be waste water or sewage. The or each mixer may be operable to entrain a flow of a fluid and solid mixture.

The angle of ejection of gas to the vertical may result in a flow component of the material in the tank around a substantially vertical axis, preferably an axis which is substantially centrally located in said tank. The angle of ejection of gas to the vertical may result in a substantially columnar flow of material. The angle of ejection of gas may result in a spiral flow of material. The angle of ejection of gas may be between about 65^0 and 85^0 to the vertical. Preferably the angle of ejection of

gas is between about 70^0 and 80^0 to the vertical, most preferably about 75^0 to the vertical.

The or each mixing device may be arranged to eject gas at an angle to a substantially radial line from the centre of the tank to an edge thereof. Said angle may be between about 35^0 and 55^0. Preferably, the angle is between about 40^0 and 50^0, most preferably about 45^0.

The or each mixer may entrain a flow which increases in volume as the flow approaches the surface of the material in the tank. The increase in volume may be caused by a reduction in hydrostatic pressure as the gas bubbles rise through the material and expand. The expanding bubbles may divide and thereby increase the disturbance to the material.

The or each mixer may be located towards the base of the tank, preferably substantially at the bottom thereof.

The or each pneumatic mixer may have a gas supply which is located externally to the tank. The gas is preferably supplied to the mixer under pressure.

The or each pneumatic mixer may have a tubular form. The or each mixer may eject gas into the interior of tube. The gas may be ejected in a forwards direction towards a first end of the tube. The gas may be ejected from an annular portion located within the tube.

The gas may be ejected from first and second regions of the mixer, which regions may be annular.

The first region may eject gas at an angle to a radial line extending from the first region to the longitudinal axis of the mixer. The gas may be ejected from a series of internal openings in the mixer, all of said openings making substantially the same angle, of preferably 29° to 31°, with a radial line extending from a respective opening to the longitudinal axis of the mixer. The gas may additionally be ejected with a forward component to its motion, by the openings making an angle of preferably about 60° to 70°, a cross-sectional plane of the mixer.

The first region may impart a rotary motion to the ejected gas, and any material entrained therein.

The second region may eject gas at an angle, of preferably 60° to 70°, to a cross-sectional plane of the mixer, to thereby preferably impart a forward motion to the gas.

The first region may be located behind the second region.

The mixer may be supplied with gas via a feed pipe of at least 1.5 cm diameter, preferably at least 2 cm diameter, most preferably at least 3 cm.

The ejection of the gas may cause material in the tank to be pulled into a second, rear end of the tube and out of the first end of the tube with the gas. The flow of material into the tube may also entrain a sympathetic flow

of material around the exterior of the tube from the second end towards the first end.

Preferably, the mixing system comprises a plurality of pneumatic mixers. The mixers may be arranged in a perimeter region of the tank, preferably spaced from the edge of the tank. The mixers may be spaced from the edge of the tank by approximately 10% of the width of the tank. The mixers may be evenly spaced around the perimeter region.

The number of mixers may be chosen so that a majority of the surface is disturbed by the action of the ejected gas entraining a fluid flow from the mixers to the surface of the material in the tank. Each mixer may create a spiral flow of material. The spiral flows may intersect as the flow increases in volume as it rises.

All of the mixers may make substantially the same angle with the vertical and/or with a radial line passing through the mixer.

The invention extends to a waste water digester tank fitted with a mixing system according to the above aspect.

According to another aspect of the invention a method of mixing fluid material in a tank comprises supplying gas to at least one fluid mixer and ejecting said gas from said mixer at an angle to the vertical to thereby entrain a flow of fluid material within the tank to cause mixing of the fluid material.

According to a further aspect of the present invention a fluid powered mixer comprises an inlet portion, a body portion and an outlet portion which define a conduit, in which the body portion is operable to direct a pressurised driving fluid into the conduit towards the outlet portion to thereby entrain a flow of material to be mixed through the conduit, in which the exterior of the mixer is shaped to enhance a sympathetic flow of material to be mixed around the exterior of the mixer from the inlet portion, over the body portion and to the outlet, wherein a first region of the body portion is operable to direct the driving fluid at an angle to a radial line extending from the first region to a longitudinal axis of the mixer, and a second region of the body portion is operable to direct the driving fluid at an angle to a cross-sectional plane of the mixer.

The first region may impart a rotary motion to the driving fluid. The second region may impart a forward motion to the driving fluid.

Preferably, the sympathetic flow is a smooth, non-turbulent flow.

The angle made between exterior surfaces of adjacent portions of the mixer may be greater than 120^0, preferably greater than 130^0, most preferably 135^0 or greater.

The mixer may have a tubular lateral cross-section.

The body portion may have an exterior surface that curves between the inlet and outlet portions, preferably with a convex curve. The body portion may have an exterior surface with a diameter which increases from a first diameter to a second diameter and decreases to the first diameter along its length. The first diameter may be a diameter of the inlet and/or the outlet portion. The second diameter may be the maximum diameter of the mixer.

The exterior surface of the body portion may have a constant radius of curvature. The exterior surface may have a radius of curvature that is greater than a maximum diameter of the mixer.

The mixer may have an exterior surface which is substantially free of projections on which solid material for mixing could snag. The mixer may have a welded construction.

The inlet, body and outlet portions may be welded together.

All of the above aspects may be combined with any of the features disclosed herein, in any combination.

A specific embodiment of the present invention will now be described, by way of example, and with reference to the accompanying drawings, in which:

Figure 1 is a schematic top view showing the layout of a fluidic mixing system in a digester tank;

Figure 2 is a partial schematic side view of the fluidic mixing system;

Figure 3 is a schematic side view of a pneumatic mixer used with the system;

Figure 4 is a schematic cross-sectional side view of an alternative embodiment of mixer;

Figure 5 is a schematic cross-sectional side view of the mixer along the line II in Figure 4; and

Figure 6 is similar to Figure 5 except is taken along line III in Figure 4.

A fluid mixing system 10 is arranged for use in a typical digester tank 11 measuring 25 metres in diameter and 30 metres in depth. An array of pneumatic fluid mixers 12 are located on the base of the tank 11.

The mixers 12 are directional jet mixers, which are directed at approximately 45^0 from a radial alignment and approximately 15^0 above the horizontal. Bio-gas (such as methane, NO_x and/or SO_x gases) is supplied to the mixers 12 from an external supply (not shown). Gas ejected from the mixers 12 entrains a flow of the waste material, which results in effective mixing thereof.

In more detail, the fluidic mixers are already known from, for instance, UK patent 2 242 370 in the name of Donovan

Graham Ellam and UK patent application 2 313 410, in the same name. However their use in this application is unique.

Figure 3 shows a schematic drawing of one of the fluidic mixers 12. Gas from a gas supply (not shown) is ejected from a perforated annulus 14 in the direction indicated by arrows A. The forward flowing gas pulls material from the rear 16 of the mixer 12, as shown by arrow B. The material and gas mixture is then forced from a front end 18 of the mixer 12, as shown by arrow C.

Gas is supplied from an exterior source through a base section 20 and support 22 to the annulus 14.

In this example, the mixers 12 have a bore of 150mm and the front end 18 is located approximately 800mm from the base of the tank 11.

Each mixer 12 is supplied with gas from a pipe 24 which runs down the side of the tank 11 (only one pipe 24 is shown in figure 2). In this example, there are eight fluidic mixers 12 which are spaced evenly around the base of the tank 11, each mixer being approximately 3 metres from the edge of the tank 11. Each mixer 12 makes an angle of approximately 15^0 with the horizontal and an angle of approximately 45^0 with an imaginary line running from the mixer to the centre of the tank.

Although this example shows eight mixers aligned in the manner mentioned above, it is of course entirely within

the scope of the invention to change the number of mixers to suit a particular tank and also to alter the alignment of the mixers.

In use, when gas is fed to each of the mixers, material is entrained with the flow of gas and sucked into the rear 16 of each mixer and ejected from the front 18. In addition to the gas from the mixers 12, methane which is produced during the processing of the material is also released.

Both the compressed gas and gas biproducts are under pressure at the base of the tank, due to the weight of the contents above. As the gas rises through the material, the pressure reduces and thus the bubble size increases. The increase in bubble size causes greater disturbance as the gases pass up towards the surface of the tank.

In a typical example, the pressure at the base of the tank may be 4 bar, with a typical volume of $12.5m^3$ transferred each minute. Using Boyle's Law $p_1v_1=p_2v_2$, then $4*12.5=1*v_2$, therefore $v_2=50m^3$ of material reaching the surface each minute. This means that there is significant movement of material within and throughout the tank 11.

Using this example the flow from each mixer 12 will result in a disturbance of up to 4 metres in diameter on the surface of the material in the tank 11.

Due to the orientation of the mixers 12, material will be caused to spiral upwards towards the top of the tank 11. In this way, material originally entrained in the flow of

gas from mixer 1 will result in a surface disturbance directly above mixer 2 (see figure 1). In the same way material entrained with mixer 2 will result in a surface disturbance directly above mixer 3, and so on.

The mixing system 10 described herein is suitable for retro fitting to an existing tank 11, because the mixers 12 can simply be secured to the base of the tank 11 by non-invasive means, such as adhesives or magnets.

In addition, the system 10 has very low maintenance costs, because the mixers and supply are very simple in construction, with no moving parts which require maintenance.

The use of the fluid mixers described herein can result in increases in efficiency of a digester tank of up to 35% over existing methods. This results in efficiency reduces the time taken to process a tank of material, which thereby results in increased capacity of the amount of material which a single tank can be used to process.

The system described herein ensures that no crust forms on the top of the contents, thereby increasing efficiency.

Although the above invention has been described in relation to waste water treatment, it is clear that the system can be used to mix many kinds of materials in a very cost effective and low maintenance set up.

As an alternative to using the fluid mixer shown in Figure 3 and described above, an alternative embodiment may use the mixer 100 shown in Figure 4.

The mixer 100 comprises a mixing chamber 101 having an inlet end 102 and an outlet end 103. Gas from a gas supply is directed to a chamber 107, from which it enters the mixing chamber 101 via a first perforated annulus 104 and a second perforated annulus 105. The chamber 107 has a bulbous housing 106 which has a smooth exterior profile.

The first perforated annulus 104 comprises a ring of openings in the body of the mixing chamber 101. The openings are angled in a forwards direction, making the angle "a" with the cross-sectional plane of the mixing chamber 101. The axis 111 of the openings 117 of the first perforated annulus 104, as well as being inclined in a forwards direction, also make an angle with a radial line of the cross-sectional plane of the mixing chamber 101. Each of the openings 117 (see figure 5) makes the same angle with the radial line passing from the opening 117 to the central axis of the mixing chamber 101. The angle may be in the range of 25° to 35° to the said radial line. The provision of the angled openings 117 allows air issuing from the openings 117 to take up a vortex type movement, as will be described below.

The second perforated annulus 105 has openings 118 (see figure 6) which are angled forwards by the angle "a" as are the openings 117. The openings 118, are not however angled in relation to radial lines from the openings 118

to the central axis of the mixing chamber 101. Consequently, the second perforated annulus 105 provides air having only a forward motion.

In use, the mixer 100 is supplied with a driving gas, typically air, from an external source (not shown). Air is supplied to the chamber 107 and issues from the first perforated annulus 104 and the second perforated annulus 105. Air issuing from the first perforated annulus 105 will have a forward and spiral type motion. When the air, and fluid entrained by the air, travelling in the spiral path passes the second perforated annulus 105 the fluid and air mixture is accelerated to increase its forward speed.

The distance between the first annulus 104 and the second annulus 105 is selected in such a manner that the longitudinal axis 111 of the openings 107 contacts the wall of the mixing chamber 101 in the same cross-sectional plane of the mixing chamber 101 as a point at which the longitudinal axis of the openings 118 intersect. The thickness of the wall of the mixing chamber 101 in the region of the first perforated annulus 104 and the second perforated annulus 105 is equal to at least twice the diameter of one of the openings 117 and 118. It has been discovered that in this case the length of the channel prevents formation of local vortices in the fluid to be conveyed with the mixer 100.

In use, the mixing fluid (air) passing through the openings 117 acquires a rotary and forward motion and when

it encounters the wall to the mixing chamber 101 forms a "high pressure ring" of the mixing fluid. The mixing fluid passing through the openings 118, which are inclined at approximately 60° to 70° to the cross-sectional plane of the mixing chamber acquires further forward motion, and owing to the arrangement of the channels ensuring the intersection of the jets of the mixing fluid at a single point 115 lying on the longitudinal axis of the mixing chamber 1 forms a "high pressure zone" along the longitudinal axis for the mixing chamber 1.

The axis of the openings 117 and 118 are arranged in such a way that the high pressure ring and the high pressure zone lie in the same cross-sectional plane 116, which is perpendicular to the longitudinal axis 12 of the mixing chamber 1. This forms a high pressure plane 116 of the mixing fluid. The functioning of the high pressure plane is reminiscent of an air piston which rotates and moves forwards towards the outlet end 103 of the mixing chamber 1, thus ensuring efficient suction from the inlet end 102 of the fluid to be mixed. In the case of gaseous mixing fluid, e.g. slurry becomes aerated which reduces its specific weight. This fact is of great importance in mixing slurries in deep tanks where, at a sufficient depth, it becomes possible to use additionally the air lift principal for the conveyance of slurry. The air lift principal is that mentioned earlier in the specification relating to the decompression of air as it rises from a deep, high pressure fluid to shallower lower pressure fluid.

The mixer 100 has a steel outer casing, with the inlet end 102 and the outlet end 103, together with the outer casing 106 having a smooth outer surface. The chamber casing 106 forms a bulbous central portion with a surface which curves between the inlet and outlet sections 102 and 103 respectively. The casing 106 is generally circular in lateral cross-section, as shown in figures 5 and 6.

The exterior surface of the casing 106 makes an angle of approximately 135° with the inlet section 102 and the outlet section 103, where each joins the outer casing 106.

Both the exterior and interior surfaces of the mixer 100 are designed to offer a minimum amount of resistance, or surface features on which solid material can snag.

In particular, when the mixer described herein is used in the treatment of waste water and sewerage, the problem of plastic bags, and other solid non-biodegrable items snagging on the mixer, as frequently occurs, is significantly reduced.

Internal constructional details of the fluid driven mixer 100 described herein have already been described in U.K. patent applications GB 2,242,370 and GB 2,313,410.

In use, a sympathetic flow of material is induced around the outside of the mixer 100, as shown by arrows f and g.

The exterior and interior surfaces of the mixer 100 described herein have significant advantages over previous

fluid driven mixers, in that the period of time over which a mixer can be run without maintenance is considerably increased, because there is a much reduced risk of the mixer suffering reduced efficiency due to partial blocking when material is snagged on a mixer.

Furthermore, the provision of the first perforated annular section 104 and a second perforated annular section 105 allows a significantly improved power delivery for the mixer, given the combination of rotary and forward motions imparted due to the orientation of the openings 117 and 118.

Furthermore, it has been determined that doubling the diameter of a supply line, and hence the amount of air supplied to the mixer 100 has surprisingly significant beneficial increases for the power output and therefore effectiveness of the mixer 100. For instance, by changing from a 1.3 cm diameter feed pipe to a 2 cm diameter feed pipe gives an increase in power of 400%. This effect was surprising to the developers of the system.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and

drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extend to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

CLAIMS

1. A fluid mixing system for a tank containing fluid material comprises at least one pneumatic mixer operable to be located within said fluid material and arranged to eject gas supplied to the or each mixer at an angle to the vertical to thereby entrain a flow of fluid material within the tank to cause mixing of said fluid material.

2. A fluid mixing system according to claim 1, wherein the system is a waste fluid mixing system.

3. A fluid mixing system according to either of claims 1 or 2, wherein the or each mixer is operable to entrain a flow of a fluid and solid mixture.

4. A fluid mixing system according to any preceding claim, wherein the angle of ejection of gas is between about 65^0 and 85^0 to the vertical.

5. A fluid mixing system according to any preceding claim, wherein the or each mixing device is arranged to eject gas at an angle to a substantially radial line from the centre of the tank to an edge thereof.

6. A fluid mixing system according to claim 5, wherein said angle is between about 35^0 and 55^0.

7. A fluid mixing system according to any preceding claim, wherein the or each mixer is located towards the base of the tank.

8. A fluid mixing system according to any preceding claim, wherein the or each pneumatic mixer has a gas supply which is located externally to the tank and is supplied to the mixer under pressure.

9. A fluid mixing system according to any preceding claim, wherein a first region ejects gas at an angle to a radial line extending from the first region to the longitudinal axis of the mixer.

10. A fluid mixing system according to any preceding claim, wherein the gas is ejected from a series of internal openings in the mixer, all of said openings making substantially the same angle, of about 29° to 31°, with a radial line extending from a respective opening to the longitudinal axis of the mixer.

11. A fluid mixing system according to claim 10, wherein the gas is additionally ejected with a forward component to its motion, by the openings making an angle of about 60° to 70°, a cross-sectional plane of the mixer.

12. A waste water digester tank fitted with a mixing system as claimed in any of claims of 1 to 11.

13. A method of mixing fluid material in a tank comprises supplying gas to at least one fluid mixer and ejecting

said gas from said mixer at an angle to the vertical to thereby entrain a flow of fluid material within the tank to cause mixing of the fluid material.

14. A fluid powered mixer comprises an inlet portion, a body portion and an outlet portion which define a conduit, in which the body portion is operable to direct a pressurised driving fluid into the conduit towards the outlet portion to thereby entrain a flow of material to be mixed through the conduit, in which the exterior of the mixer is shaped to enhance a sympathetic flow of material to be mixed around the exterior of the mixer from the inlet portion, over the body portion and to the outlet, wherein a first region of the body portion is operable to direct the driving fluid at an angle to a radial line extending from the first region to longitudinal axis of the mixer, and a second region of the body portion is operable to direct the driving fluid at an angle to a cross-sectional plane of the mixer.

15. A fluid powered mixer according to claim 14, wherein the angle made between exterior surfaces of adjacent portions of the mixer is greater than 120°.

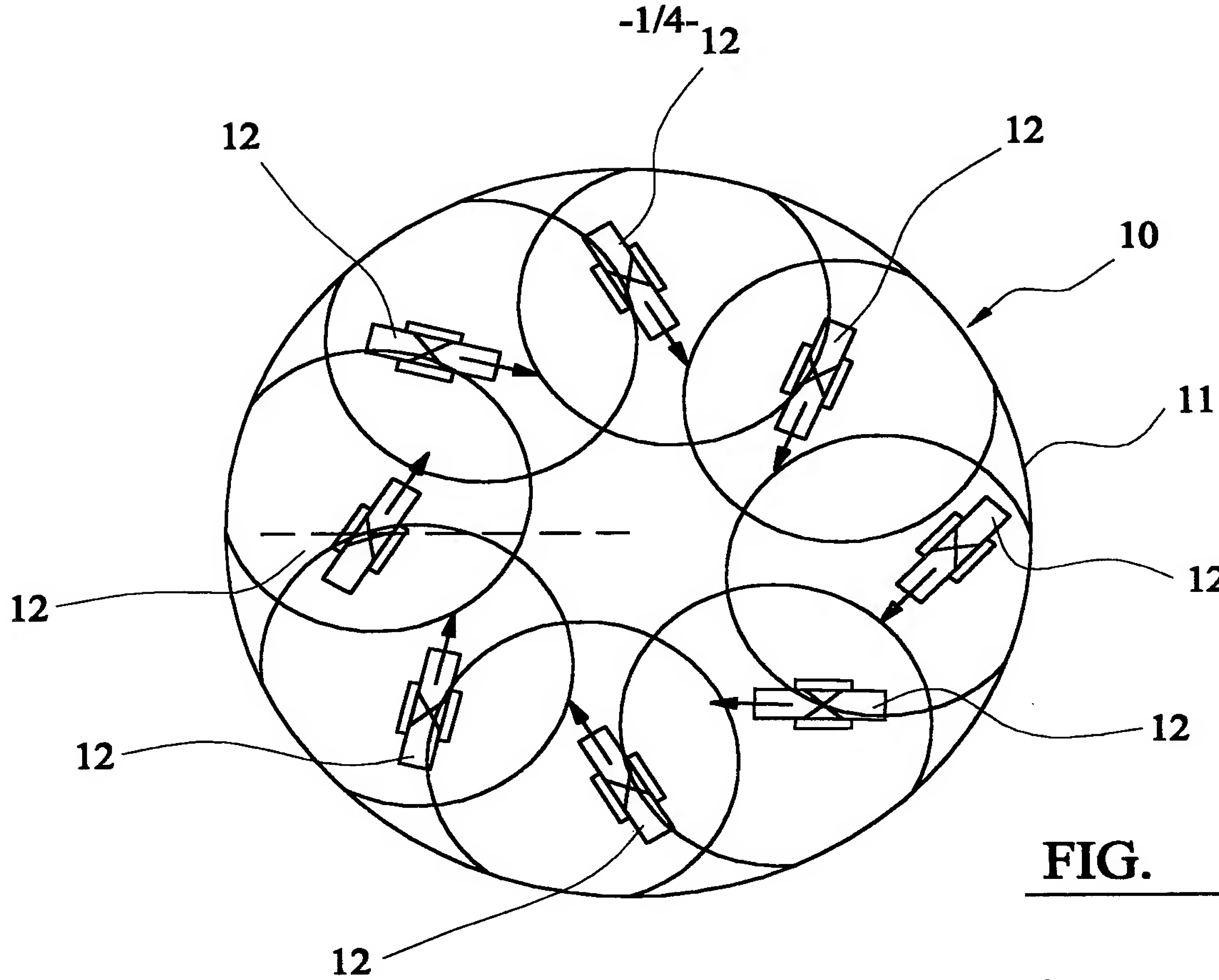


FIG. 1

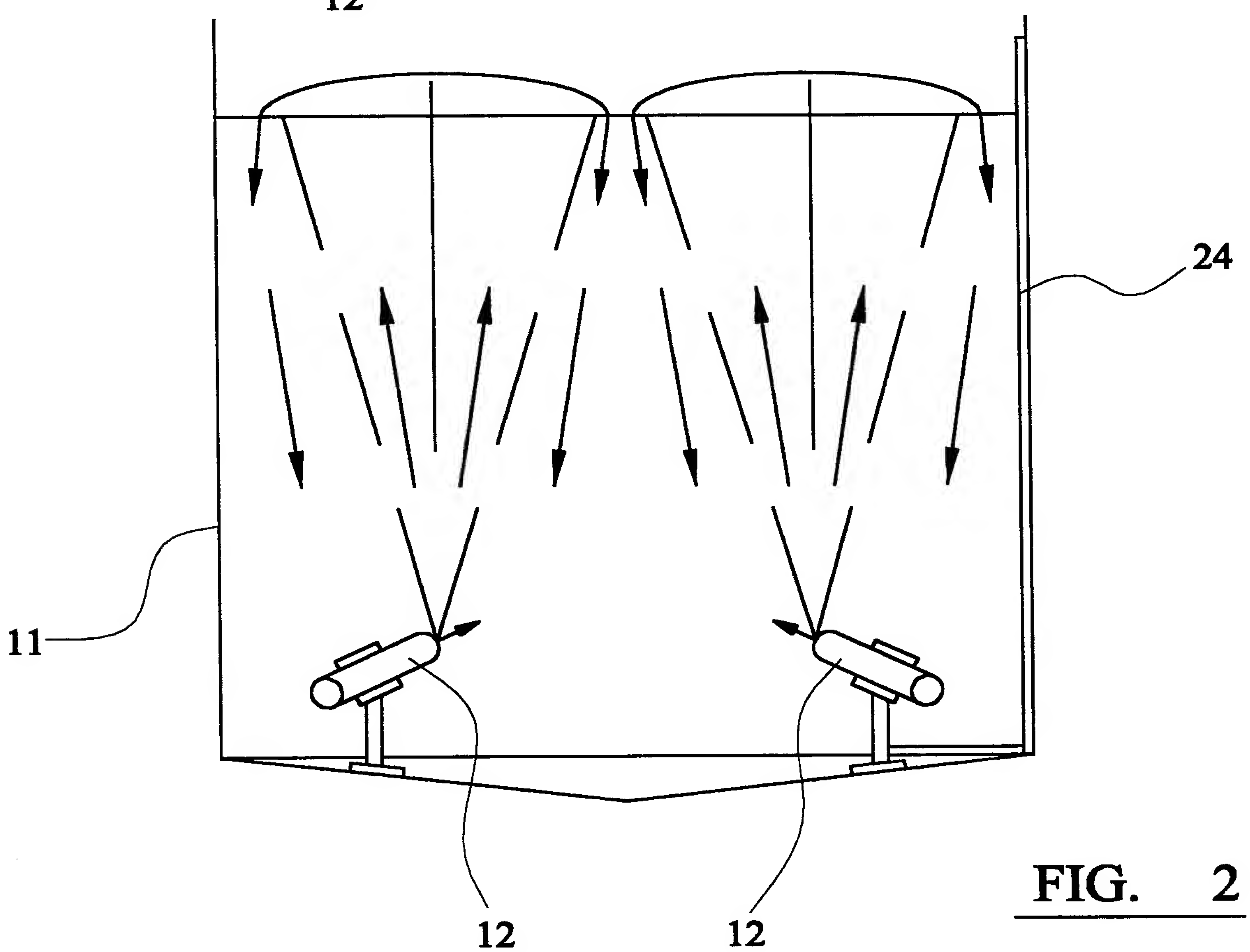


FIG. 2

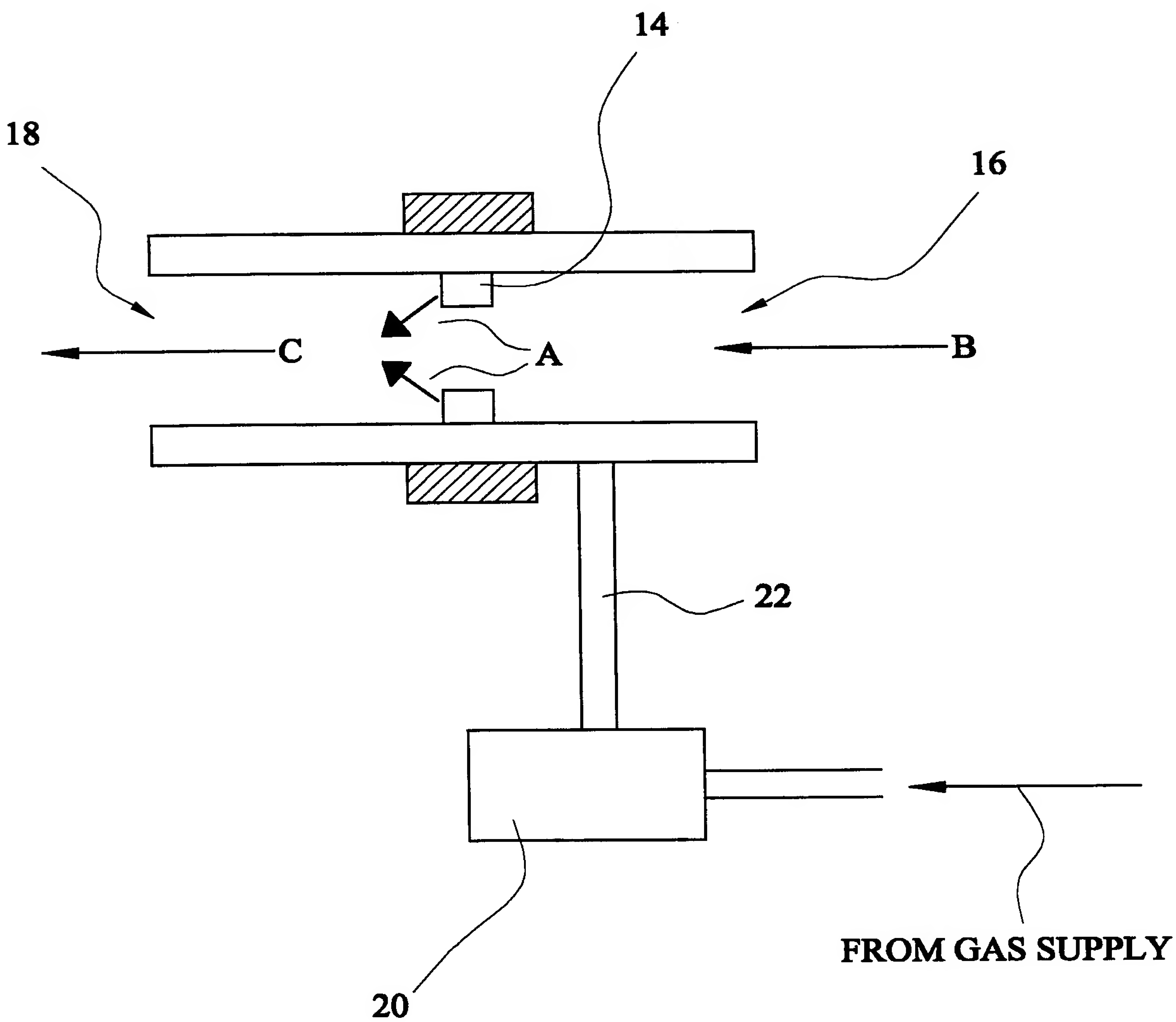


FIG. 3

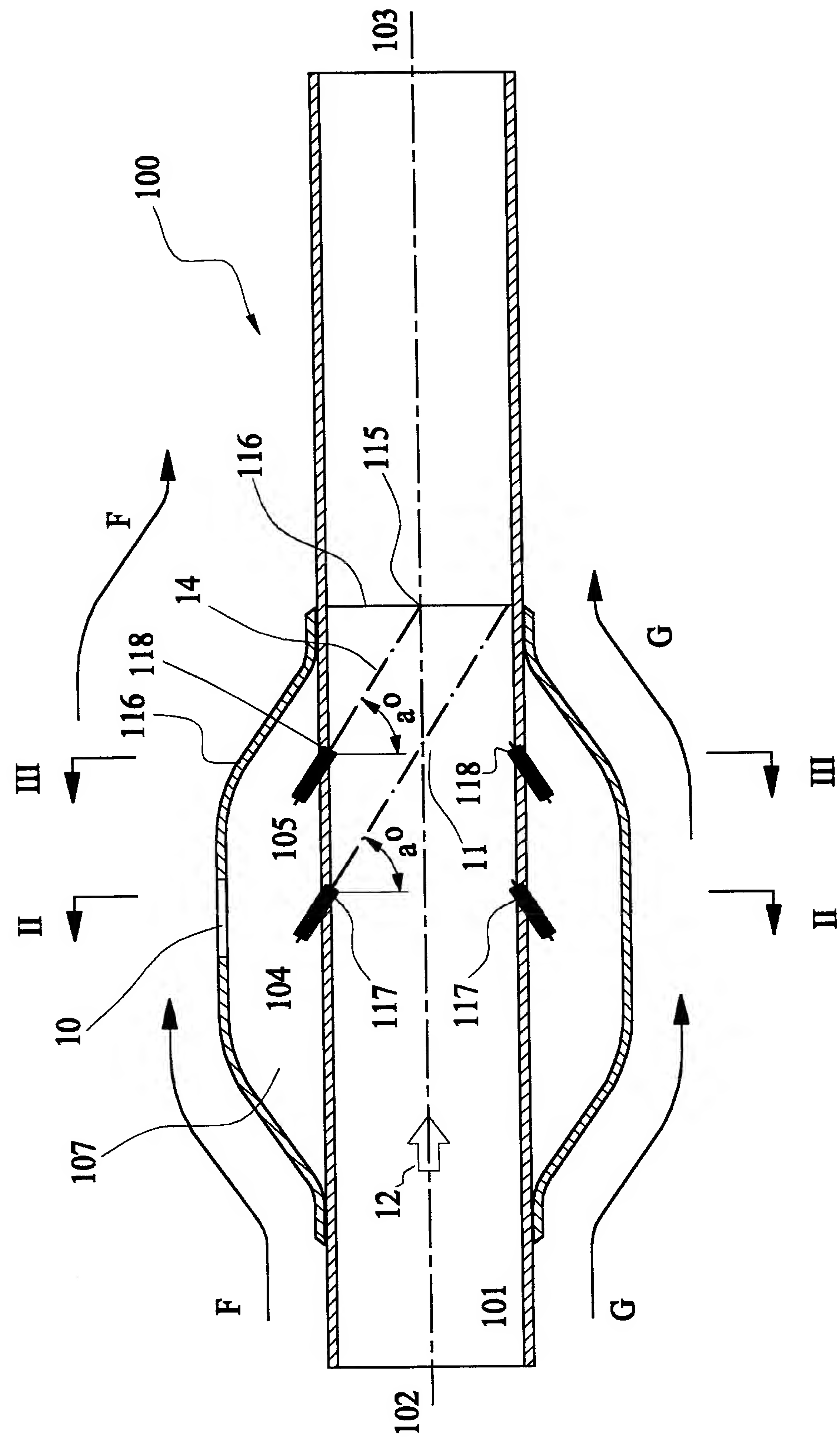

103
100
116
115
F
14
118
116
G
III
III
105
11
118
II
II
10
104
117
117
107
12
F
101
G
102

FIG. 4

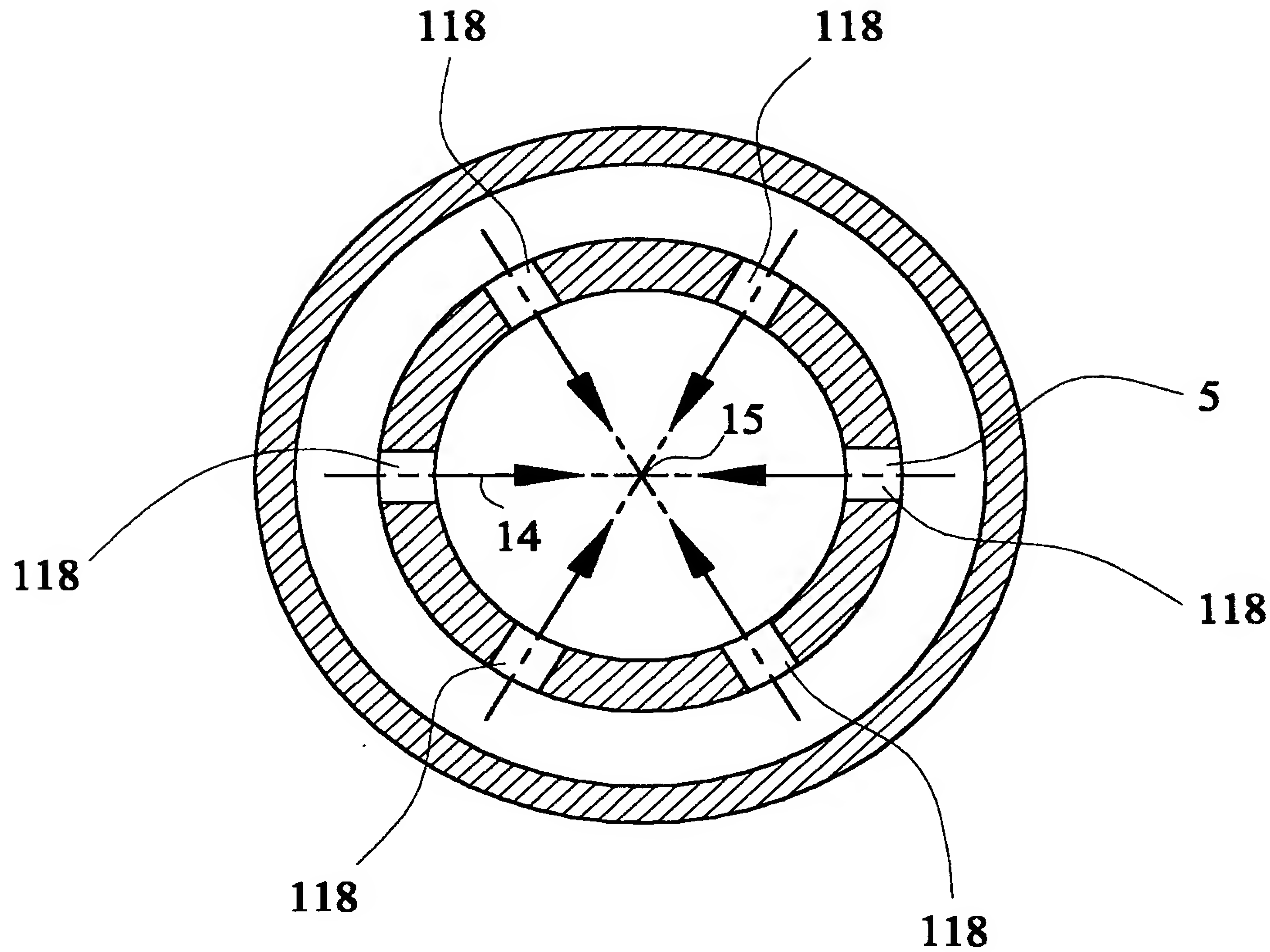


FIG. 6

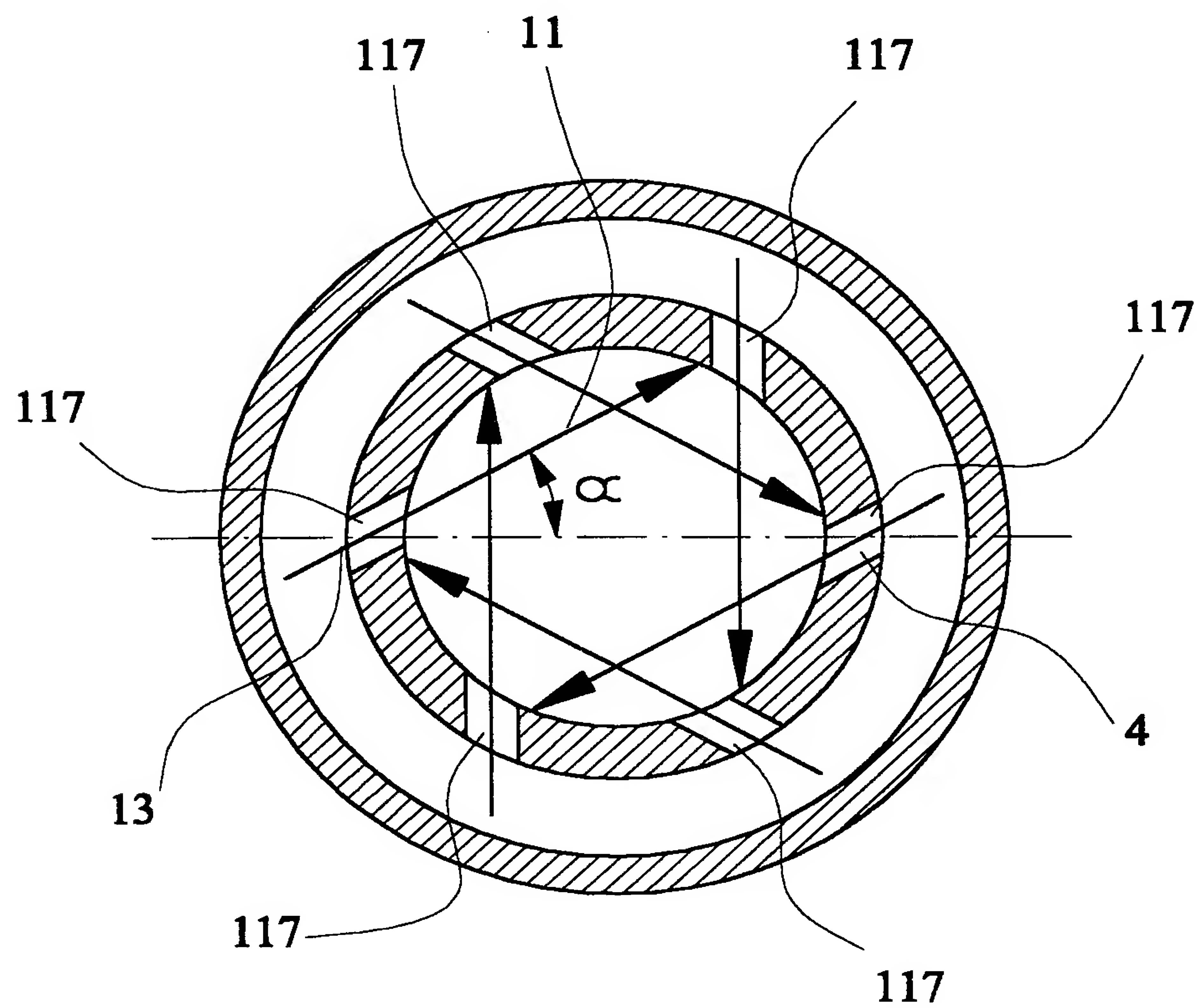


FIG. 5

INTERNATIONAL SEARCH REPORT

Inter onal Application No
PCT/GB 00/01755

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01F3/04 C02F3/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01F C02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 4 097 026 A (HAINDL KAREL) 27 June 1978 (1978-06-27) column 3, line 21 - line 27; figures 1,2	1-4,7,8, 12,13 5,6,9-11
Y	DE 26 20 139 A (STRATE WILHELM FA) 24 November 1977 (1977-11-24) figure 1	5,6
Y	US 4 028 009 A (ZAICHENKO MIKHAIL EFIMOVICH ET AL) 7 June 1977 (1977-06-07) claims 1,2; figures 1-3	9-11,14, 15
Y	US 3 829 070 A (REBA I ET AL) 13 August 1974 (1974-08-13) figure 5	14,15

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 September 2000	15/09/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Belibel, C

1

Form PCT/ISA/210 (second sheet) (July 1992)

Inter onal Application No
PCT/GB 00/01755

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 569 575 A (AIR LIQUIDE) 7 March 1986 (1986-03-07) figures ---	1,2,4,7, 8,13
A	GB 1 092 871 A (ASENDORF K. E.) 29 November 1967 (1967-11-29) figures ---	1-8,12, 13
A	DE 12 75 512 B (WALBERSDORF W.) 22 August 1968 (1968-08-22) figures ---	1,4,13
A	WO 85 03458 A (PARKS RICHARD E) 15 August 1985 (1985-08-15) abstract; figures -----	1,2,7,8, 12,13

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 00/01755

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 4097026	A	27-06-1978	CS	176645	B	30-06-1977
			CA	1036152	A	08-08-1978
			JP	1237532	C	31-10-1984
			JP	51087862	A	31-07-1976
			JP	59012334	B	22-03-1984
DE 2620139	A	24-11-1977	NONE			
US 4028009	A	07-06-1977	NONE			
US 3829070	A	13-08-1974	NONE			
FR 2569575	A	07-03-1986	NONE			
GB 1092871	A		BE	656072	A	
			DE	1459453	A	30-01-1969
			FR	1414505	A	10-01-1966
			NL	6413469	A,B	21-05-1965
			SE	316427	B	20-10-1969
DE 1275512	B		NONE			
WO 8503458	A	15-08-1985	AT	43253	T	15-06-1989
			AU	3996485	A	27-08-1985
			CA	1253853	A	09-05-1989
			DE	3570370	D	29-06-1989
			EP	0171431	A	19-02-1986
			JP	6049143	B	29-06-1994
			JP	61501081	T	29-05-1986
			US	4595296	A	17-06-1986